# Three-Dimensional Cortical Morphometry of the Planum Temporale in Childhood-Onset Schizophrenia

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*Objective:* *Anomalous planum temporale asymmetry has been linked to both schizophrenia and dyslexia. The authors examined the planum temporale of adolescents with childhood-onset schizophrenia who had a high rate of prepsychotic language disorders.* *Method:* *Planum temporale area and asymmetry were measured in 16 right-handed adolescent patients with schizophrenia who had experienced onset of psychosis by age 12. The same measures were made in 16 healthy adolescents matched for age, sex, and handedness.* *Results:* *No differences between the healthy adolescents and those with schizophrenia in planum temporale area or asymmetry were observed. Prepsychotic language disorder predicted abnormal planum temporale asymmetry in the adolescents with schizophrenia.* *Conclusions:* *These findings do not support anomalous planum temporale asymmetry as a basis for psychopathology in childhood-onset schizophrenia.*

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One source of support for the neurodevelopmental model of schizophrenia has been the postmortem and in vivo observation of abnormal cerebral asymmetry in this disorder (1–3). The planum temporale shows a prominent leftward (left greater than right) asymmetry in 70% of healthy individuals (4). In the language-dominant hemisphere, the planum temporale coincides with the speech region of Wernicke (5), and abnormal planum temporale asymmetry has been associated with dyslexia (4). Examination of the planum temporale in schizophrenia has yielded conflicting results: some investigators found decreased asymmetry (1, 2), some found reversed asymmetry (3), and some found no differences in asymmetry in patients with schizophrenia compared with control subjects (6, 7). Observed gender differences in abnormalities of planum temporale asymmetry in schizophrenia have also been inconsistent (1, 2).

In the present study, planum temporale morphology and asymmetry for 16 adolescent patients with childhood-onset schizophrenia were contrasted with those of 16 matched healthy subjects. Given the early disease onset, more severe and treatment-refractory course, and greater frequency of prepsychotic language disorders in these patients (8), we hypothesized that anomalous planum temporale asymmetry would be more severe or more homogeneous in our patients and would be associated with a history of prepsychotic language disorder.

## METHOD

Of 29 9–18-year-old patients with DSM-III-R-diagnosed treatment-refractory schizophrenia and premorbid full-scale IQ of at least 70 recruited nationally using previously reported screening procedures (9), 16 patients were selected to match healthy subjects in age, sex, and handedness. The patient group included eight girls and eight boys whose mean age was 13.5 (SD=2.4) and whose mean age at onset of psychotic symptoms was 10.0 years (SD=2.2). Review of neuropsychological reports and school and medical records from the prepsychotic period of all patients indicated that six of the patients (two girls and four boys) were diagnosed as having a language disorder during this period (8).

Sixteen healthy subjects (eight girls and eight boys) whose mean age was 13.9 years (SD=2.1) were screened using previously described procedures (9). Given the evidence for less leftward asymmetry of the planum temporale in left-handed subjects (4), only right-handed healthy subjects and patients with schizophrenia were included in the present study.

Parents of all subjects provided written informed consent, and the subjects themselves provided assent for participation in this study, which was approved by the National Institute of Mental Health Institutional Review Board.

An axial dataset of 1.5-mm thick contiguous slices was acquired from each subject, and total cerebral volume was quantified using

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**TABLE 1. Planum Temporale Area and Asymmetry of 16 Adolescents With Childhood-Onset Schizophrenia and 16 Healthy Adolescents Measured Using Three Methods**

| Measurement Method and Subjects | Left Planum Temporale ($cm^2$) | | Right Planum Temporale ($cm^2$) | | Asymmetry[a] | | Asymmetry Classification | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD | Leftward Asymmetry | Symmetric | Rightward Asymmetry |
| Method 1: completion of anterior planum temporale border with line perpendicular to midsagittal plane | | | | | | | | | |
| Adolescents with schizophrenia | 6.06 | 1.72 | 4.14 | 1.61 | −0.38 | 0.44 | 13 | 1 | 2 |
| Normal adolescents | 5.53 | 1.74 | 4.48 | 2.70 | −0.32 | 0.54 | 11 | 1 | 4 |
| Method 2: completion of anterior planum temporale border with line maintaining angle of Heschl's sulcus to midsagittal plane | | | | | | | | | |
| Adolescents with schizophrenia | 6.65 | 1.81 | 4.42 | 1.69 | −0.41 | 0.43 | 13 | 1 | 2 |
| Normal adolescents | 5.83 | 1.76 | 4.70 | 2.77 | −0.32 | 0.57 | 10 | 2 | 4 |
| Method 3: method 1 plus removal Heschl's gyrus tissue overlapping planum temporale | | | | | | | | | |
| Adolescents with schizophrenia | 7.28 | 2.14 | 4.68 | 1.71 | −0.43 | 0.39 | 14 | 0 | 2 |
| Normal adolescents | 6.56 | 2.11 | 4.82 | 2.87 | −0.40 | 0.49 | 11 | 1 | 4 |

[a] $\delta$=(right−left)/(0.5[right+left]).

methods described elsewhere (9). The method for segmentation and measurement of the planum temporale was adapted from that of Kulynych et al. (7) and is fully described elsewhere (10). Briefly, axial datasets were aligned and resliced to create sagittal datasets. Boundaries were then identified in serial sagittal sections for both left and right planum temporale as follows: the origin of the posterior ascending ramus marked the posterior boundary of the planum temporale, and Heschl's sulcus formed the anterior boundary. The lateral rim of the supratemporal plane formed the lateral border of the planum temporale, and the retroinsular point where the anterior and posterior borders of the planum temporale coincide formed the medial border.

Surface renderings of the segmented sagittal datasets were generated as described elsewhere (10). Regions of interest encompassing the planum temporale were drawn manually on these renderings. When Heschl's sulcus did not extend fully to the lateral rim of the supratemporal plane, the anterior border of the planum temporale was completed in two ways: 1) a line perpendicular to the midsagittal plane was drawn from the lateral end of Heschl's sulcus to the lateral border of the planum temporale; and 2) a line maintaining the angle of Heschl's sulcus to the midsagittal plane was drawn from the lateral end of the sulcus to the lateral border of the planum temporale. In a third method, 3) Heschl's gyrus tissue overlapping the planum temporale was removed to expose the rostral extent of the planum temporale.

Segmentation and measurement of the planum temporale were performed by two raters blind to the subject's identity (C.T. and L.K.J.). Five brains (10 plana temporale) were segmented and measured twice by each rater to determine interrater reliability, which was 0.92 for method 1, 0.90 for method 2, and 0.94 for method 3.

Group differences in area of the planum temporale were examined using repeated measures analysis of variance and analysis of covariance with diagnosis as a between-subject factor, side as a within-subject factor, and total cerebral volume as a covariate. Planum temporale asymmetry was also examined by computing an asymmetry coefficient—$\delta$=(right−left)/(0.5[right+left])—and classifying subjects as leftwardly asymmetric ($\delta<-0.05$), symmetric ($-0.05<\delta<0.05$), or rightwardly asymmetric ($\delta>0.05$) (11). All p values are two-tailed.

## RESULTS

There were no significant differences between healthy adolescents and those with schizophrenia in age, height, weight, or Tanner stage. On average, the total cerebral volume of the patients with schizophrenia was 9.3% smaller than that of the healthy adolescents (t=2.86, df=30, p<0.01).

Mean planum temporale area, mean asymmetry coefficient, and asymmetry classification obtained for both groups using each of the three methods are shown in table 1. Analysis of variance and analysis of covariance revealed no significant diagnostic differences for left or right planum temporale area regardless of the method used to complete the anterior boundary of the planum temporale.

All methods demonstrated significant leftward asymmetry across groups (method 1: F=14.28, df=1, 30, p<0.001; method 2: F=15.32, df=1, 30, p<0.001; and method 3: F=31.66, df=1, 30, p<0.001). There were no group differences in asymmetry (side-by-diagnosis interactions). Mean asymmetry coefficients were negative for both groups for all methods and did not significantly differ. Asymmetry classifications did not differ between patients with schizophrenia and normal adolescents. Gender-specific comparisons also revealed no diagnostic differences for planum temporale area or asymmetry for either boys or girls.

Within the group of patients with schizophrenia, a history of prepsychotic language disorder was associated with abnormal asymmetry (rightwardly asymmetric or symmetric) for all three methods ($\chi^2$=6.15, df=1, p<0.05 for methods 1 and 2 and $\chi^2$=3.81, df=1, p=0.05 for method 3).

## DISCUSSION

The planum temporale has been linked to language processing (4) and to schizophrenic pathology (1–3). However, consistent with the pattern of relative sparing of temporal lobe structures observed in this group of

patients (9), no abnormalities in the morphology and asymmetry of this structure were found. These observations suggest that earlier onset of schizophrenia is not associated with a more severe superior temporal gyrus or planum temporale lesion and that abnormal neurodevelopment in schizophrenia begins some time after planum temporale asymmetry is established—after the 34th–36th week of gestation (12).

Subtle abnormalities of anatomic asymmetry, functional asymmetry, cytoarchitectonic organization, or synaptic connectivity in the region of the planum temporale in patients with schizophrenia cannot be ruled out by these findings, however. Similarly, conclusions regarding gray matter underlying the planum temporale, which has been found to be reduced in adults with schizophrenia (13), cannot be made from these data.

The observed relationship between history of prepsychotic language disorder and abnormal planum temporale asymmetry in the adolescents with schizophrenia suggests that discrepancies in the literature on planum temporale asymmetry in schizophrenia may reflect differences in the frequency of premorbid language disorders across study samples.

Future studies will include longitudinal follow-up of these patients to determine whether anomalous planum temporale asymmetry develops later in the course of schizophrenic illness.

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